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AN OVERVIEW: GINGER, A TREMENDOUS HERB

Muhammad Shoaib[1,2,*], Aamir Shehzad[1*], Masood Sadiq Butt, Muhammad Saeed[1], Husnain Raza[1,2], Sobia Niazi[1,2], Imran Mehmood Khan and Azam Shakeel[1]

[1]National Institute of Food Science and Technology, FFNHS, University of Agriculture, Faisalabad, 38040, Pakistan
[2]State Key Laboratory of Food Science and Technology, Synergetic Innovation Center of Food Safety and Nutrition, School of Food Science and Technology, Jiangnan University, Wuxi, Jiangsu, People's Republic of China
[*]Corresponding author's e-mail: shoaib_ju@hotmail.com,draamir@uaf.edu.pk

Novel nutritional approaches are becoming a major modifiable determinant of chronic diseases. Scientific evidences have supported dietary intervention as an effective tool for healthy life style. In this context, functional foods and nutraceuticals may provide a mean to reduce the increasing burden on health care system by a disease preventive mechanism. Ginger has many biologically active components like polyphenols and flavonoids contain health related properties including anticancer, antiviral and antihypertensive. This review will cover all the aspects of bioactive components of ginger and their healthbenefits especially hypocholesterolemic and hypoglycemic role.

Keywords: Ginger, functional food, bioactive components, extraction methods, anti-oxidant property, Hyperglycemic, and hyper-cholesterolemic effect

INTRODUCTION

Currently, the establishment of links between health and food has been diverting the consumer focus, towards plant based functional and nutraceutical food products instead of synthetic medicines for curing numerous philological disorders (Chauhan *et al*., 2013). Changing lifestyle of people along with poor cultural habits have enforced researcher to find out diet based therapies that are cost effective and safe. In this regard, functional and nutraceutical foods not only fulfill nutritional requirements but also provide medicinal benefits. Now a days, functional and nutraceutical food has become an integral component of diet owing to its therapeutic potential against various lifestyle related disorders like hypercholesterolemia, cardiovascular diseases, hyperglycemia and cancer. In diet-based therapies, indigenous herbs and plants have gained much importance.

Diet based therapy has been invigorated worldwide and people are using natural food materials as a remedy against various maladies. Amongst, different dietary regimen tools plant phytochemicals have engrossed attention due to their acceptability, safety and health improving characteristics (Thielecke and Boschmann, 2009). Phytochemicals have the ability to perform various biological functions like reducing oxidative stress and degenerative ailments, metabolic disorders owing to their intrinsic antioxidant potential (Manach *et al*.,2004). In this regard, functional/nutraceutical foods are being formulated to improve the health (Rains *et al*., 2011).

Nutraceutical and functional foods are gaining much popularity and capturing the global market. Now a days, more than 470 nutraceutical and functional food items are marketed with proved health claims (Eskin and Tamir, 2006). The statistics analysis of market shows that worth of nutraceuticals and functional foods was estimated above $197 billion and 30-60 billion US$ in Japan and USA respectively. The term functional food was defined as "Food which not only provides basic nutrients but also possesses many therapeutic benefits". The division between functional and nutraceuticals foods is that the nutraceuticals foods are enriched with active components to get targeted health benefits.The utilization of these products not only aimed to get health benefits, besidesthey can also have preventive and curative effects for many ailments ranging from cardiovascular diseases to cancer (Girgih, *et al*., 2013).

Researchers have confirmed that various phytochemicals and bioactive components are present in these indigenous herbs and medicinal plants that ensure their medicinal attribute and thus are an important part of modern functional and nutraceutical foods. Researches have also depicted that a handsome number of phytochemicals and bioactive moieties are present in herbal plants among them ginger (Zingiberofficinale) has rich phytochemical profile as it possesses nutraceutical potential against various physiological threats especially due to the presence of 6-gingerol (Karam and Bhavna, 2013).

The inclusions of processed foods, changing living patterns and irregular dietary habits are the leading causes of physiological disorders and diet related complexions like diabetes, cancer, CVD, and high cholesterol levels are increasing day by day. Prevention from these disorders is a major public health concern worldwide especially in

developed and underdeveloped nations. Then involvement of phytochemicals in diet for diseases prevention was widely spread and documented from ancient times due to their safer and high pharmacological values (Chen *et al*., 2008). Recently, analysis proves therapeutic properties of diet have created a revitalization to improve human health and nutrition research (Misra*et al*.,2008). Nutraceuticals have been claimed to have a physiological benefit or provide protection against the many diseases (and/or found to act as) Cardiovascular agents, Antiobese agents, Anti-diabetics, Anticancer agents, Immune boosters, Chronic inflammatory, disorders Degenerative diseases. Among these ailments, very common one are obesity, CVD, High serum triglyceride level, declined levels of high density lipoproteins (HDL), hypertension and impaired glucose tolerance.

Worldwide, the burdens of chronic diseases like cardiovascular diseases, cancers, diabetes and obesity is rapidly increasing. In 2001, chronic diseases contributed approximately 59% of the 56.5 million total reported deaths in the world and 46% of the global burden of disease. Cardiovascular diseases (CVD) is the name for the group of disorders of the heart and blood vessels and include hypertension (high blood pressure), coronary heart disease (heart attack), cerebrovascular disease (stroke), heart failure, peripheral vascular disease, etc. In 1999 CVD alone contributed to a third of global deaths and by 2010 it would be the leading cause of death in developing countries. Majority of the CVD are preventable and controllable. It was reported that low intake of fruits and vegetables (Temple and Gladwin, 2003) is associated with a high mortality in cardiovascular disease Many research studies have identified a protective role for a diet rich in fruits and vegetables against CVD (Hu and Willett, 2002). This apart, nutraceuticals in the form of antioxidants, dietary fibers, omega-3 polyunsaturated fatty acids (n-3 PUFAs), vitamins, and minerals are recommended together with physical exercise for prevention and treatment of CVD (German and Walzem,2000).

Thus, the researchers are taking keen interest in the identification of natural remedies to handle the metabolic syndromes. In the past, researches have depicted that the good health is associated with pharma foods. Food products, which are prepared to attain higher quantities of essential bioactive nutrients and phytochemicals as compared to naturally existing components in the reference foods are known as pharma foods. Dietary supplements or food stuffs with various concentrations of micronutrients and other substances offer significant clinical and therapeutic benefits. A combination of several ingredients is used to achieve a specific set of goals (Kim *et al*., 2013).

In recent era, use of ginger as nutraceutical in functional foods is in fame. In medicinal plants, (Zingiberofficinale) commonly known as Ginger or 'Adrak' has gained much importance. Ginger has been used in foods and medicines from ancient times. From previous few decades, massive research has been done to explore the pharmacological characteristics of a delicate and attractive spicy herb known as scientific name Zingiberofficinale.Ginger rhizome is a product of Zingiberofficinale plant. It is a monocotyledon herbaceous plant of the tropical and subtropical region. It belongs to the sub-family Zingiberoideae, which is also very famous for two spice crops i.e. turmeric and cardamom. The genus Zingiber Boehm consists of 80-90 species of rhizomatous perennial herbs, very ordinary in South-East Asia, Japan, India, Nepal, China, Bangladesh, Queensland, Jamaica, Mexico, Hawaii and Pakistan (Grant and Lutz, 2000). India is the largest producer with production of ginger more than 30% of the world share followed by china 20.5% and Indonesia, Nepal and Nigeria produces 12.7%, 11.5%, 10%, respectively. According to the (FAO, 2011) total area of ginger cultivation of Pakistan is about 152 heaters with annual production of 115 tons. Ginger is comprehensively investigated for therapeutic purposes against various diet related diseases (Butt and Sultan, 2011).

Fresh ginger rhizome is composed of fat (1.0%), minerals (1.2%), protein (2.3%), fiber (2.4%), carbohydrate (12.3%) and water (80.7%). The minerals present in ginger are sodium, potassium, calcium, magnesium iron, and phosphorous (Jolad *et al*., 2004). The concentration of volatile oils in the ginger ranges 1-3% and the aroma and flavour are also dependent on these compounds. The volatile aromatic compounds of ginger are lost during drying or thermal processing due to which aroma and flavour of dry ginger is different form fresh ginger (Evans, 2002).

Ginger rhizome is also composed up of extractable oleoresin, fats, carbohydrate, vitamins, minerals, and some other bioactive components (Shukla and Singh, 2007). The extract is a combination of gingerols, shogaols, zingerone, monoterpenic, and sesquiterpenic compounds constituting about 3-7% of the total weight of fresh ginger. In the ginger oil gingerols are the main pungent and concentrated molecules. Gingerols are very sensitive towards heat on high temperature they are converted into a homologous series of degraded compounds (6, 8, 10 shogaols) that hold strong antioxidant activity (Kelly *et al*., 2002). Pretreatment of ginger inhibits the induced hyperglycemia, hyperinsulinemia and hyperlipidemia (Akhani *et al*., 2004).

The typical method for ginger extraction, such as solvent extraction has several drawbacks as it employ large amounts of chemical solvents and is time consuming. Recently, the supercritical fluid extraction (SFE) is commonly used to get extract from natural products. It is referred as a very effective replacement of traditional extraction methods. It gains much fame in food and pharmaceutical industry due to due to its natural, pure and safe end products. Besides this it is very valuable for extraction of heat sensitive constitutes (Diaz-Reinoso *et al*., 2006). The ginger extracts produced from supercritical carbon dioxide extraction are free from chemical solvents, providing a significant advantage in their potential

appliance as useful ingredient for the food industry (Puengphian and Sirichote, 2008). No doubt a lot of extraction techniques are used to get the ginger extract but the extract obtained through the supercritical fluid extraction technique by using CO_2 as solvent is very pure and same in composition as in the roots (Bartley and Jacobs, 2000). These both techniques are differentiated by their end products. The end product of steam distillation is essential oil and solvent extraction is oleoresin (Ibrahim, 2006). The concentration of oleoresin produced by using different organic solvents is about 4-7.5% of dry powder. Its contains zingiberol, the principal aroma contributing component as well as gingerol, shogaols, paradols, zingiberene, gingediol, diarylheptanoids, vitamins and phytosteroles (Balachandran *et al*., 2006).

Many food industries like meat, dairy and baking use the extract of different plants and spices to increase the sensorial attributes and their antioxidant potential. These extracts have a great impact on the shelf life of different food products especially bakery items like crackers, cookies, bread, and biscuits are of great economic benefits. Reddy (2005) reported the antioxidant response of many plants extract and their ultimate use in food items.

Mainly the bioactive ingredients, like gingerol, shogaols, zingerone and many others, serve as a source of aroma and flavor; the baking conditions of bread are very adverse for aromatic compounds. They are easily decomposed with heat because by definition, they are somewhat volatile at the mouth temperature. Generally, liquid flavors are not recommended in baked goods, such as crackers and hard type of sweet. Thus ginger extract may be better for texture than the powder of ginger. In recent years, in view of their advantageous effects, use of spices has been progressively rising in developed countries as well as used in phytotherapy especially in Europe (Langer *et al*., 1998). In Pakistan, the use of functional and nutraceutical foods is growing rapidly. Although ginger is a regular ingredient of Pakistani foods yet little or no efforts have been made to use this health ingredient in commercially available processed foods.

Previously, several human illnesses have been treated by using ginger rhizome extract. Functional and nutraceutical ingredients present in ginger rhizome have hypocholesterolemic and hypoglycemic effects especially antioxidants, fat-soluble vitamins, phytosterols and some pyrazanol containing moieties (Singh *et al*., 2008; Matsuura *et al*., 2008). The gingerol shows antioxidant (Masuda *et al*., 2004), and anti-inflammatory behavior (Lantz *et al*., 2007). 1 g of ginger powder on an average contained 2.56 mg, 0.47 mg 0.36 mg and 1.27 mg of 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaols, respectively (Schwertner and Rios, 2007). The antioxidant activity of ginger extract is depend on the concentration of 6-gingerol in the extract. In a study, it was investigated the concentration 6-gingerol is highly related to the antihyperlipidemic effects of ginger extract in fructose induced hypolipidemic rats (Goyal and Kadnur, 2006). Kadnur and Goyal, (2005) explored the effectiveness of ginger extract by orally administration at the dose of 100, 200, 400 mg/kg for 60 days in hyperinsulinemic and hyperglycemic rats. It significantly affects the lipid profiles, water and feed intake, serum glucose level and body weight, total cholesterol, LDL cholesterol, free fatty acid, and phospholipids induced by high-fat diet (Nammi *et al*., 2009).

From the above discussion it has been concluded that ginger is rich source of phytochemicals with key health benefits. It also has a tremendous anti-diabetic and cholesterol lowering ability.

PHARMA FOODS; A NOVEL TREND

Changing lifestyle and people's concern about healthy and nutritious food have encouraged them to select the food which has health promoting potential along with providing basic nutrients. Plants are the basic source of food. The plant originated foods not only scavenge our appetite but also provide some therapeutic effects due to their bioactive moieties. The modern researches are proving the therapeutic effects of different phytochemicals without any toxic effects. (Pandey, 2013). Food products, which are prepared to attain higher quantities of essential bioactive nutrients and phytochemicals as compared to naturally existing components in reference foods are known as pharma foods. Functional and nutraceutical foods have shown high potential to improve consumer health as well as to alleviate disease risks. Lately, scientific research has radically recommended the use of phytochemicals as a diet based regimen to secure the well-being of human health against certain lifestyle related maladies as obesity, hyperglycemia and hypercholesterolemia (Shahidi, 2009).

All over the world, pharma foods are attaining much attention owing to their disease preventive potential. These functional and nutraceutical foods provide a way to reduce health care expenditures which cause economic burden in human society. Selection of healthy diet ultimately results in prevention of diseases and now consumers are more conscious about their food (Gidding *et al*., 2005; Urala and Lähteenmäki, 2007). From last few decades, consumers have changed their living manners and food consumption patterns. Globally, various legislations and health policies had been implemented, especially, in Western countries which emphasis on the improvement of food quality (Schwager *et al*., 2008).

In the last few years, trend is markedly increased towards the use of nature based medicines as compared to the synthetic medicines. The history proves the use of different herbal remedies and many dietary supplements to mitigate many ailments without any physician recommendation (Li *et al*., 2013). According to the modern researches, it was investigated to be unsafe practice. E.g. many herbal drugs which are administrated to cure they are lacked in researched data with their therapeutic effects and safety (Engdal *et al*.,

2009). It is common observation that peoples mostly relay on the historical accounts regarding the effectiveness and safety of these herbal-medicines. This misleads the users and maybe detrimental (Pittler *et al*., 2005). Human beings rely on the plant for the food and physiological needs from centuries. In the plants, herbs and spices holds a key position due to their nutritional and medicinal profiles, still 80% of the global population consider botanical preparations as a medicine to meet their physiological threats (Yanishlieva *et al*.,2006).

Herbs and spices are extensively grown in many Asian, African, and others countries for the culinary purpose. In the past few years a lot of research has been conducted to evaluate the medicinal values of the herbs and spices, due to which increasing trend is observed in the many European and developed countries to mitigate the different ailments. In this context, Germany is the top of the list with (49%) share, France and UK (10%) each, Spain, Holland, Belgium 2% and Europe with (15%) are positioned, respectively. In the Europe these condiments are commonly used due to their therapeutic effects. Among the culinary herbs ginger is very commonly used in different medicines in USA and India (Peter, 2001).

Currently, main stress of food technologists and nutritionists of the world is to classify the essential food nutrients and to explore their health enhancing potential. The understanding of bioactive components and their health promoting behavior provided the basis of dietary guidelines (Marriott, 2000; Liu-Stratton *et al*., 2004; Butt *et al*., 2007). Meanwhile, China and Mediterranean countries were concerned in the exploration of non-nutritive phytochemicals and bioactives for their disease preventing potential (Marriott, 2000; Tanaka *et al*., 2001). At the beginning of 21st century, consumer awareness and development of innovative products led to the formation of functional and nutraceutical foods, which minimized the risk of illnesses through their disease preventing mechanism (Bárta *et al*., 2006; Zock and Katan, 2008).

Nutraceuticals are frequently confused with functional foods and are also intermingled with phytochemicals. Functional foods are defined by the American Dietetic Association (2005) as the foods which provide health benefits along with basic nutrients. Recent advancements in the field of food and nutrition focus on the utilization of functional foods and it will become the largest adaptive trend in coming decades. Nutraceuticals are huge in number and this category includes almost all types of fruits, vegetables, enriched or fortified and dietary supplemented foods (Jones and Varady, 2008). With increasing awareness people are more adaptive towards nutraceutical foods and green tea, juices, vegetables and grain based products are popular food of choices in market.

A diet rich in phytochemicals or bioactive components is a food of choice for present community because it shows disease defensive mechanism. People consuming functional and nutraceutical diets have lower risk of illnesses, so they enjoy healthy life for long period of time (Vina *et al*., 2006; Bjelakovic *et al*., 2007; Jenkins *et al*., 2008). Among new generation cardiovascular disorders like heart attack, blood pressure and other such ailments are spreading widely. The causes of these life threatening ailments include unhealthy lifestyle, poor eating habits and consumption of junk foods. Moreover, sedentary lifestyle and lack of exercise is also a major contributor of these ailments. Research has proved that a diet rich in phytochemicals from plant source such as ginger is helpful in combating cardiovascular disorders (Retelny *et al*., 2008).

Pakistan is blessed with sources of foods that are rich in bioactives and phytochemicals. The addition of these components in daily diet can enhance the health status (Khattak *et al*., 2008; Butt *et al*., 2007). Among herbs and spices, ginger is helpful in fighting against many diseases like diabetic mellitus (Kanter, 2008), hypercholesterolemia, cardiovascular disorders (Ebru *et al*., 2008), chronic inflammation (Al-Othman *et al*., 2006; Sethi *et al*., 2008), immune dysfunction, respiratory disorders and various types of cancers (Al-Johar *et al*., 2008). Nutritional profile of ginger makes its components of interest for research scholars. The health benefits of ginger are associated with its bioactive components.

Many pharmacological Preparations and medicine are prepared from ginger from hundreds of years. Ginger is also used to treat many lifestyle related disorders like hypercholesterolemic, hyperglycemic, CVD, Cancer, Nausea, Vomiting etc. Most commonly ginger is available in the market as fresh, besides this; it is also available in dried, pickled, tincture, extract, oleoresin capsules or tablet form. It is also incorporated into different food items like bakery products, beverages, meat products, and many other food items as flavour agent along with medicinal benefits. Now a day's ginger powder and extract is also used in salads, soups, stews, casseroles, etc. in addition to give them specific taste, flavour along within maintaining health. Among these herbs and spices ginger holds a strong position due to its assenting health claims.

GINGER: AN OVERVIEW

***Botanical Review*:** Ginger (Zingiberofficinale) commonly known as "Adrak" widely used in Pakistani and Indian cuisines over 2500 years (Bartley and Jacobs, 2000).It belongs to family "Zingiberaceae" which is very famous due its medicinal herbal plants like, cardamom and turmeric (Park *et al*., 2006). It has been cultivated in South-East Asia from thousands of years. After that it gains much popularity in European and African countries due to its therapeutic effects. Currently, the ginger and its products are used in many traditional medicinal systems, due to its rich phytochemistry and diseases preventive properties (Shukla and Singh, 2007).

Historic Review: Ginger is a magnificent pungent spice with a great history of cultivation. It is mentioned in the Holy book of Muslims, which indicate that Arabian peoples are well

familiar with ginger science 650AD. India is the largest producer of this herb and it is used in Indian and Chinese traditional medicines to treat many disorders over 5000 years. Many health claims of ginger were documented in many countries like in China it is used to cure abdominal distensions, coughing, vomiting, diarrhea, rheumatism, and toothaches over 2500 years, and for yellow fever, malaria and urinary tract infections in Nigeria and West Indies. It was migrated to Europe during Roman and Greek times. Ginger is one of the oldest spices used in Europe, in the 9th century. Due to its carminative affects, the Greek peoples directly incorporated it into bread and generated the idea of ginger incorporation in food products. In India still 25% peoples prepare the cough syrup from ginger and honey to get relief from common cold (Grant and Lutz, 2000).Ginger is known by different names in different languages like in Arabic "Zanjbeel" Frech "Gingembre" etc. Ginger is advanced and modified name of different words. Historically on the basis of its appearance linked with Sanskrit word "Srngaveram" means "Horn root", in Greek with "Ziggiberis" and in Latin, "Zinziberi". In Indo-Pak in Urdu it is known as "Adrak".

***Usage, Preparation and Processing*:**The advancement in the technology brings a revolution in all the disciplines of the life. For instance, it makes easy to preserve the food commodities for the days of shortage. In case of ginger, if we see the market it is available in both fresh and processed forms. The well-known and commercially available products of ginger are powdered, pickled, candied, crystallized, preserved ginger and ginger essential oils/ oleoresin. The harvesting of ginger also depends upon its final use. Mostly, for the fresh consumption ginger rhizome is harvested after 5 months at immature stage. If the ultimate objective is to prepare powder, extract and essential oil from the rhizome then it is harvested at fully mature stage at the age of 8-9 months for the application in food and pharmaceutical products. The products prepared from mature ginger are incorporated in cookies, cakes, and curry mixes. The pink colored common product of ginger is pickle of ginger in vinegar. Crystallized ginger is cooked in sugar syrup and coated with granulated sugar. Ginger is also a good source of different nutraceutical components that's why now a day's ginger extract and essential oil is gaining much fame in nutraceutical food products and pharmaceutical industry.

***Chemistry of Ginger*:** Ginger is very excellent source of a variety of biologically active components, which shows remarkable pharmacological and physiological benefits. The well reputed and most pungent bioactive molecule of ginger is 6-gingerol. The use of ginger and ginger products is commonly considered as safe but still more researches are needed to understand the complete mechanism behind its therapeutic effects (Tapsell *et al*., 2006). Due to the phytochemical profile and pharmacological properties, the ginger and ginger products are widely administrated into human diet to diminish different kind of ailments such as colds, nausea, arthritis, migraines, diabetes mellitus, CVD, and hypertension etc (Ali *et al*., 2008; Nicoll and Henein 2009).

Fresh ginger rhizome is composed of fat (1.0%), minerals (1.2%), protein (2.3%), fiber (2.4%), carbohydrate (12.3%) and water (80.8%). The minerals present in ginger are sodium, potassium, calcium, magnesium iron, and phosphorous (Odebunmi *et al*., 2009). The distinct aroma of fresh ginger comes from volatile oils ranging from 1-3% (Evans, 2002). The bioactive components which possess pharmacological activities are of two types discussed below.

***Volatile Oils*:** Volatile compounds are those components which have very low boiling point and can easily evaporate from the commodity even at room temperature. In the ginger, concentration of these compounds is about 1-3%. The main moieties in the volatile oil of ginger include zingiberene, curcumene, and farnesene having respective percentages 35%, 18%, 10%. In addition, about 40 different molecules are present among which most abundant compounds are 1, 8-cineole, linalool, borneol, neral, and geraniol (Evans, 2002; Sasidharan *et al*., 2012). The pungent aroma and taste of the ginger is mainly depends on these volatile constituents (Shukla and Singh, 2007). The flavoring properties of the ginger oil are affected by processing conditions; different constituents are degraded into less flavoring compounds (Evans, 2002).

***Non-Volatile Pungent Compounds*:** The Non-volatile components of ginger are more appreciated due to their high biological and pharmacological value. The principle constituents of Non-volatile oil are gingerols, shogaols, paradols and zingerone that produce a ''hot'' sensation in the mouth. The gingerols are the main bioactive components that show numerous health benefits in many studies. The key elements gingerols are a chain of homologs molecules, which are characterized on the bases their unbranched alkyl chains length (Jaleel and Sasikumar, 2012). In addition, like gingerols, shogaols are also homologous series of compounds. During the processing, the gingerols are converted into the shogaols and show more pungency as compared to the gingerols. Sometimes these are referred as the dehydrated product of gingerols (Wohlmuth*et al*., 2005). All these compounds are interlinked with each other for example paradols is similar to gingerol and produced upon the hydrogenation of gingerols (Shukla and Singh, 2007). In the recent study Wohlmuth *et al*. (2005) studied that among the phenolic components of ginger 6-gingerol is the most abundant compound with small quantities of other gingerols. The pungency increased due to the degradation of gingerols into the shogaols during thermal processing. The stability of gingerols is also depends on different parameters like, type, origin, cultivar, pH, temperature, etc. Bhattarai *et al*. 2001 described the reverse degradation of shogaols into gingerols and effect of pH on it. It is reported that at pH 4 and temperature 100^{o}C, 6-gingerol is rapidly degraded into the 6-

shogaol and at pH 1 and same temperature the process is reversed. Some other components are also produces due to high temperature a compound zingerone is also produces which is less pungent and give spicy-sweet aroma (Harold, 2004). In this study, we are dealing with the gingerols of ginger. Due to their sensitive nature the novel techniques were used for their extraction and their safe application in food products.

***Other Constituents*:** Ginger also applied into in the dairy products due to its proteolytic enzymes. Zingbain is the famous proteolytic enzyme of ginger. Ginger is also a good source of different vitamins, waxes, carbohydrates and minerals (Shukla and Singh, 2007).

FACTORS AFFECTING ACTIVE COMPONENTS COMPOSITION

***Thermal Treatment/Drying Process*:** It is commonly observed that the heat treatments not only change the physical state of the product and also have significant effect on chemical state. Just like that in the dehydration of ginger some constituents of ginger are degraded into new compounds. The concentration of 6-gingerol is decreased from 21.15 to 18.81 mg/g dry weight basis. Due to the thermal conversion of compounds the antioxidant activity of dried ginger was significantly increased then the fresh ginger. This trend is well elaborated in different antioxidant assays. In the DPPH assay, described as EC50 the antioxidant activity was increased as 64.60 and 32.95 µg/mL in dried and fresh ginger respectively. While in the ABTS assay the values of fresh and dried ginger were 169 and 403.71 µmolTrolox/g extract and total phenolic contents were 24.63 and 59.80 mg gallic acid/g extract, respectively. Drying process of ginger caused a significant increase in the total phenolic content, contributing to stronger antioxidant activity (Puengphian and Sirichote, 2008). The thermal degradation products of 6-gingerols including shogaols and aliphatic aldehydes possibly occurred during the drying process (Bhattarai *et al*., 2001) and these exhibit antioxidant activity. In some studies, it was investigated that the total phenolic content of ginger also increased (Ismail *et al*., 2010: Chan *et al*., 2009). This increase in phenolics is relates with the release of the bounded phenolics due to destruction of cellular constituents and formation of new compounds with higher antioxidant values (Jang *et al*., 2007). Lim and Murtijaya, (2007) described that the declines in the antioxidant potential has been related to the degradative enzymes of phytochemicals, by which they loss their therapeutic and pharmacological properties. TPC and DPPH radical-scavenging activity increased or remained unchanged depending on the type of vegetable and not on the type of cooking (Turkmen *et al*, 2005; Roy *et al*., 2007).

***Type of Cultivar*:** The composition of bioactive components varies with type of cultivar. The quantitative analyses of 6, 8, and 10-gingerols and 6-shogaol in the CH_2Cl_2 extracts of Chinese white and Japanese yellow gingers by (Ali *et al*., 2008) showed that gingerols were in higher concentration among both Chinese while and Japanese yellow ginger varieties. But their presence in the yellow variety was at a higher concentration (47%) than in the while variety (16%). On further analysis it was concluded that the concentration of 6-gingerol about 34% and 28% in the yellow and white varieties, respectively, followed by 10, and 8-gingerol. The presence of 6-shogaol at a meager level of 0.35% in both varieties suggests that it could be either an artifact derived from 6-gingerol via dehydration during processing or a naturally occurring minor constituent.

***pH*:** It was also revealed that the rate of degradation of 6-gingerol to 6-shogaol was found to be pH dependent. The maximum stability was recorded at pH 4, whereas at pH 1 and 100 °C. The reverse degradation was comparatively rapid (Bhattarai *et al*., 2001).

***Extraction Methods and Analytical Techniques*:** Essential oils, from ginger rhizome can be separated by multiple extraction methods such as conventional solvent extraction, steam distillation microwave/enzyme assisted extraction and supercritical fluid extraction technique. Steam distillation is different from solvent extraction because it is to produce essential oils, but solvent extraction produces oleoresins. The steam extracts the essential oils of ginger from the rhizome and then condensed through the condenser into liquid phase. Finally, the two liquids are separated (Ibrahim, 2006).

Rhizomes of dried ginger contain both pungent and aromatic components. Ginger flavor containing both pungent and aromatic components is preferred in the flavor industry but at the same time recovery of both components has not been possible by conventional extraction processes. For example, steam distillation process can't recover the pungent components since the dominant pungent components as gingerols are thermally degraded to volatile aldehydes or ketones (Bhattarai *et al*., 2001). The oleoresin extracted with solvents (ethanol or acetone) followed by evaporation process has less aroma due to the loss of volatile component. In a study, ethanol (2% mass) increased the yield by 10% for Australian ginger when used as co-solvent as compare to the yield obtained by using pure liquid CO_2 at 25°C, however the yield decreased when temperature was raised to 35°C (Francisco and Dey, 2003).

The typical methods for ginger extraction, such as steam distillation or solvent extraction have several drawbacks as they employ large amounts of chemical solvents and are time consuming. Recently, the supercritical fluid extraction (SFE) process has been introduced which is playing an increasingly important role in extraction from natural products. The SFE is a technology of interest to the food and pharmaceutical industries, as an alternative to conventional processes because it produces extracts that are free from residues. Moreover, it can be conducted al moderate temperatures to preserve the quality of products that are heat sensitive. In addition, from

the supercritical carbon dioxide extraction, the extract can be regarded as all natural with the GRAS status for food applications (Diaz-Reinoso *et al*., 2006). The ginger extract produced from supercritical carbon dioxide extraction was also free of chemical solvents, providing a significant advantage in their potential application as functional ingredients for the food industry (Puengphian and Sirichote, 2008). Although various extracts arc obtained from ginger, it is the CO_2 extracts that are richest in polyphenol compounds and have a composition that is closest to that of the roots (Bartley and Jacobs, 2000).

There is difficult to obtain pure compounds by conventional column chromatography separation methods because of their unstable chemical properties and structural similarities (Grzanna *et al*., 2005; Schwertner and Rios, 2007). Recently high-speed 17 counter-current chromatography is gaining interest in the isolation of bioactive components from the crude material (Frighetto *et al*., 2008; Zhan *et al*., 2011) because it is a supper-free liquid-liquid partition chromatographic technique with no irreversible adsorption onto solid support and has an excellent sample recovery (Wang *et al*., 2011).

Wang *et al*. (2009) reported for the first time the preparative separation of gingerols by high-speed counter-current chromatography in stepwise elution. Followed by an initial clean-up step on silica column, high-speed counter-current chromatography (HSCCC) was used to purify gingerols from an extract of the dried ginger. From 360 mg of pre-purified sample, 132 mg of 6-gingerol, 31 mg of 8-gingerol, and 61 mg of 10-gingerol was yielded and purity determined by HPLC was over 98% for each compound.

Zancan *et al*. (2002) studied the effects of pressure, temperature and addition of co-solvents (ethanol and isopropyl alcohol, both at 1.17% (mass) on the kinetics of the extraction of ginger oleoresins. The substances present in the oleoresin were identified by GC-MS and GC-FID techniques were used for the determination of composition of ginger extract. The results showed that the temperature and interaction of pressure and solvent affected the total yield significantly. It was concluded that the mass transfer rate had increased with pressure in the absence of co-solvent and decreased when co-solvents were used. The amounts of the major substances of the ginger extracts (α-Zingiberene, gingerols and shogaols) were affected by pressure, temperature and solvents significantly. However, the antioxidant activity of the extract of ginger was remained constant at 80% and decreased to 60% in the absence of gingerols and shogaols.

Balladin *et al*., (1998) quantitatively and qualitatively analyzed West Indian ginger for its principal pungent constituents using HPLC and pungency profile of extracted ginger oleoresins was evaluated from fresh, solar dried and solar dried/steam distilled rhizomes. It was investigated that the total oleoresins extracted from fresh, dried and stem distilled ginger rhizome was in ratio of 20:1:2 with respect to the gingerols contents. The ratio of the pungent principles was 1:5:1 with 32% losses with respect to the principal pungent constituents extracted from fresh rhizome when compared with solar dried ginger rhizomes. For pungency profile, it was observed that total gingerols contents were in 8:1 ratio for fresh and solar dried ginger rhizomes. The solar dried ginger rhizomes had shogaols in higher amount which might have been produced by the dehydration of gingerols.

For the determination of chemical composition or ginger extract, ginger oleoresins were extracted with the help of CO2 and solvents, (Gas chromatography/mass spectrometry (GC/MS) was used for the identification of the components present in the oleoresins and GC-FID was used for the determination of composition of ginger extract. The chief substances in die ginger extracts were identified as α-Zingiberene, gingerols and shogaols. The amounts of these compounds were significantly affected by solvents, temperature and pressure (Zancan *et al*., 2002).

The most suitable HPLC method has been developed for the quantification of 6- gingerol, 8-gingrol, 10-gingerol and 6-shogaols in a variety of ginger containing food products, teas, spices, mints, beverages, and dietary supplements. Gingerols were extracted with ethyl acetate from various ginger containing food products and then analyzed by HPLC at 282 nm on C-8 reverse phase column. From the dietary supplements and ginger containing food products, the recoveries of 6-gingerol 8-gingerol, 10-gingerol and 6-shogaols were 94.7%, 93.6%, 94.9%. 97.1% respectively. With ethanol as an extraction solvent, the recoveries of 6-gingerols and 6-shogaols with a single extraction were more than 98%. The 6-gingcrol concentrations in the various ginger supplements were greater than that of the 8-gingerol or 10-gingerols concentration, But not always greater than that of 6-shogaol. 1 g of ginger powder on an average contained 2.56mg, 0.47mg, 0.36mg and 1.27mg of 6-gingerol, 8-gingerol and 10-gingerol and 6-shogaols respectively. 6-gingerol was about 0.256% of the dried ginger powder on weight basis whereas the 8-gingerol, 10-gingerol and 6-shogaol made up 0.047%, 0.036% and 0.127% of ginger powder respectively (Schwertner and Rios, 2007).

A gradient elution reversed phase HPLC separation system of ginger extract has been developed which had better separation results as compared to previous isocratic ginger extract separations. To identify the principal pungent components in the chromatogram of ginger extract, HPLC UV electrospray MS was successfully used. Based on UV spectra, M1H, M1N and characteristic sodiated dimmers 2M1Na ions, and comparison of data against purified standards of 6-gingerol and 6-shogaol, he positively identified seven major pungent constituents of ginger as 6-gingerol, 8-gingerol, 10-gingerol, 6-shogaol, 8-shogaol 10-shogaol and 6-gingediol. Another eight minor components were identified tentatively as analogues of gingerol (Ghasemzadeh *et al*., 2010).

***Health Effects: The Scientific Evidence*:** The plants are the good source of phytochemicals which significantly possess the antioxidant and reduces many ailments like oxidative stress, cancer, mutagenic, diabetes, CVD, infections, inflammation and other carcinogenic conditions. The linkages between the diabetes with other complications and the confirmation of side effects of the synthetic medicines the researchers are focusing on the development of botanical novel anti-diabetic drug (Kota *et al*., 2012).

In this context, due to rich phytochemistry ginger is considered as remedy for many health complications from cold to cancer, from thousands of years. It is a good source of many functional and nutraceutical components gingerols, shogaols and paradolsetc (Ali *et al*.,2008). All these components have been shown strong antioxidant potential and helpful in scavenging the free radicals. The administration of ginger in the in vivo studies on rats claimed many therapeutic effects like improvement antioxidant status, prevention from lipid peroxidation, carcinogens, glucose and LDL lowering effects and many others (Nirmala *et al*., 2010). The evidence for the effectiveness of ginger as an antioxidant, hypocholesterolemic, hypoglycemic, anti-inflammatory, anti-nausea, and anticancer agent as well as the protective effect of ginger against other disease conditions are claimed.

Antioxidant properties of ginger

Free radicals are the highly reactive moieties produced during food processing and in biological systems in result of many generative and degradative reactions. Many health problems linked with advancement in food processing, dietary habits and free radicals production. In such conditions of imbalance, extra antioxidant supplementation through dietary modules is essential for organism vitality (Chen *et al*.,2008).

Antioxidants are those compounds which eliminate these active moieties by binding them with own active sites and reduce the risk of different health complications. In this scene, plant based foods are considered as good source of antioxidants. Among vegetables ginger has many therapeutic effects to mitigate such kind of health discrepancies (Ramaa *et al*., 2006). In many in vitro studies ginger exhibit strong antioxidant activities, due to its active constituents like gingerols, shogaolsetc (Kota *et al*., 2008).

The use of ginger in diet improves the body defense system. It has been proved in many in vitro studies that many chronic diseases are associated with oxidative stress, to prevent these conditions ginger have protective effects due to high antioxidant activity of active components (Shukla and Singh, 2007). If oxidative stress retained for a longer period of time it leads to DNA damage (Hussein *et al*., 2005). The gingerols are considered as the enzyme inhibitor. It hinders the activity of different enzymes e.g Xanthine oxidase. Which are involved in the production of reactive radicals (Huang *et al*., 2012). Among the ginger active components gingerols are considered as strongest antioxidant nutraceutical components. They have proven substantial antioxidant activity in different antioxidant assay (Dugasani *et al*., 2010). The nutraceutical ingredients of ginger like gingerols possess substantial antioxidant activity as determined by various antioxidants assays. In the DPPH assay 6, 8, 10-gingerol and 6-shogaol shows significant scavenging activity with IC50 values of 26.3, 19.47, 10.47, and 8.05 muM respectively. IC50 values of 4.05, 2.5,1.68, and 0.85 muM against superoxide radical and IC50 values of 4.62, 1.97, 1.35, and 0.72 muM against hydroxyl radical, respectively (Dugasani*et al*., 2010).

It was documented that the extracts of ginger have shielding consequence against ethanol-induced hepatotoxicity in the rats by suppressing the age-related oxidative stress markers (Topic *et al*., 2002; Mallikarjuna *et al*., 2008). Chrubasik *et al*. (2005) investigated that the oxidative stress in Chinese hamster ovary AS52 cells and promyelocutic leukemia (HL)-60 cells of humans can easily be suppressed by the use of ginger and its constituents. In the several studies, it was reported that gingerols have a significant inhibitory activity on superoxide production, restrain lipid peroxidation and defend the levels of reduced glutathione (El-Sharaky*et al*., 2009).

Ippoushi *et al*. (2003) find out that the nitrogenous free radicals like "nitric oxide" (NO) are the key moieties which manipulate different health issues through signal transduction and DNA damage. These reactive molecules are produced by the action of enzyme nitric oxide synthase (iNOS) excreted in the stress conditions. The action of this enzyme and production of nitric oxide can be significantly reduced by the 6-gingerol administration on dose dependent manner.

Like gingerols the other elements (6-Shogaol, 1-dehydro-10-Gingerdione, and 10-Gingerdione) of ginger also significantly trim down LPS-induced NO production, and 6-shogaol and 1-dehydro-10-gingerdione efficiently lessen iNOS expression (Park *et al*., 2012). El-Sharaky *et al*. (2009) documented that the oral administration of ginger at 100mg/kg of body weight efficiently decreased the glutathione level and normalizes the nitric oxide (NO) generation in bromobenzene (BB)-induced hepatotoxicity model. In a study, it was described that the activities of superoxide dismutase and catalase, as well as GSH and glutathione peroxidase, glutathione reductase, glutathione-S-transferase, and lipid peroxidation in animal models have been reduced by the use of ginger (Ahmed *et al*., 2007).

Ginger supplementation before ischemia/reperfusion resulted in a higher total antioxidant capacity (i.e., normalized glutathione peroxidase and superoxide dismutase activities) and lower total oxidant (lower tissue malondialdehyde, NO, and protein carbonyl contents) status levels compared to an untreated group of Wistar albino rats (Uz*et al*., 2009). In the ischemia/ reperfusion oxidative stress conditions rats fed on diet containing 5 % ginger experienced less kidney damage (Uz *et al*., 2009). In the biomodeling trails free radicals are produced in the rat's body by using different chemicals. And the effect of ginger extract results in significantly reduction in

lipid peroxidation and the level of antioxidant enzymes along serum gluthathione (El-Sharaky *et al*., 2009).

Gingers Hyperglycemic/ Anti-Diabetic Effects: The change in the dietary style and low physical activity generates many lifestyle related disorders like blood pressure, obesity, CVD and many others. Among these Diabetes mellitus is rapidly growing health complication and one of the foremost reasons of casualties in the world. In a survey, it has been estimated that if this diseases remain increasing with the current rate then in 2030 it will harm about 367 million peoples worldwide (Lapshina *et al*., 2006). It is a persistent metabolic disorder occurs in result of lower physiological activity and high caloric intake (Eckel *et al*., 2005). In this context, scientist and doctors are trying to explore anti-diabetic activity of different plants based food items. In the past few years the effectiveness and anti-diabetic activity of ginger has been tested in many studies and it is proved as a safe herbal medicine.

Bhandari and Pillai,(2005) studies on that the oral administration of ethanolic ginger extract in rabbits has significantly reduce the blood glucose level. Another study was conducted to explore the cholesterol reducing effect of ginger extract by (Al-Qattan *et al*., 2008) in which aqueous ginger extract was given at dose of 500 mg/kg of rats for 4 weeks. The hematological studies proved that ginger extract subsequently reduces the fasting blood glucose level. The anti-diabetic activity of ginger extract is depends upon the concentration of 6-gingerol. It enhances insulin-sensitive glucose uptake by stimulating the differentiation of 3T3-L1 preadipocytes (Sekiya *et al*., 2004). Akhnai *et al*.,(2004) reported that the ginger juice significantly cures the 5-hydroxytryptamine-(5-HT-) induced acute hyperglycemia. It was also conclude from study that in STZ-induced diabetic rats oral glucose tolerance test shows that ginger consumption significantly reduces the area under the curve of serum glucose level and increases the area under insulin curve.

Commonly conventional solvents are considered as best extraction medium for 6-gingerol. The methanol gives best results as compared to the other organic solvents. Kadnur and Goyal, (2005) examined that the methanolic extract of ginger is also more effective in reducing lipid profiles, body weight, glucose and insulin levels in the fructose induced hyperglycemic rats. Its activity depends on the higher concentration of 6-gingerol present in it. Bhandari*et al*. (2005) compared the anti-diabetic potential of dried ethanolic extract against the standard anti-hyperglycemic drug "Gliclzide". The ginger extracts oral administration for 20 days shows significant hypoglycemic effect comparison of drug.

Likewise Han *et al*. (2008) explored that aqueous extract of Zingiberofficinale reduces the hydrolysis of triolein emulsified with phosphatidylcholine by pancreatic lipase in vitro and reduced the elevation of rat plasma triacylglycerol levels after oral administration of a lipid emulsion containing corn oil. Recently, Al-Amin *et al*. (2006) studied the hypoglycemic potentials of ginger in streptozotocin (STZ)-induced diabetic rats given an aqueous extract of raw ginger daily (500 mg/kg, intraperitoneally) for a period of 7 weeks. Blood serum from fasting animals was analyzed for glucose, cholesterol and triacylglycerol levels. The STZ-injected rats exhibited hyperglycemia accompanied by weight loss. At a dose of 500 mg/kg, raw ginger was significantly effective in lowering serum glucose, cholesterol and triacylglycerol levels in the ginger-treated diabetic rats compared with the control diabetic rats.

The ginger-treated diabetic rats sustained their initial weights during the treatment period, decreased water intake. Thus, ginger may be of value in managing the effects of diabetic complications in human subjects. Aldose reductase inhibitors are now considered to have remarkable potential for the treatment of diabetes and its complications without increased risk of hypoglycemia (Ali *et al*., 2008). In a study concluded that ginger has glucose lowering effect in the normal rats after the 1 hour of administration (Ojewole, 2006).

In the STZ- induced diabetic rat models investigated that ethanolic extract of ginger (800mg/kg) significantly lower the blood glucose concentration after 1 hour of administration. Its highest activity was recorded after 4 hours, where it showed dose (100-800 mg/kg) dependent decrease in blood glucose level about 24-53% (Ojewole, 2006). In the streptozotocin-induced diabetic rat model, rats that were fed ginger exhibited better glucose tolerance and higher serum insulin levels than untreated rats, suggesting that it could help control blood sugar levels (Islam and Choi 2008). Further-more, Nammi *et al*. (2009) assert that the ethanolic extract of ginger at 100, 200, and 400 mg/kg body weight reduced body weights and levels of glucose, insulin, total cholesterol, LDL cholesterol, triglycerides, free fatty acids, and phospholipids in high-fat diets (Ojewole, 2006). Recently, Heimes *et al*. (2009) supported the hypoglycemic potential of ginger. Islam and Choi (2008) suggested that ginger has insulin optropic properties that are mainly attributed to its glucose-lowering potential (Sekiya *et al*., 2004; Goyal and Kadnur, 2006; Heimes *et al*., 2009).

A later study showed that-shogaol or -gingerol significantly inhibited TNF-α-mediated downregulation of adiponectin expression in 3T3-L1 adipocytes (Isa *et al*., 2008). Islam and Choi (2008) have explored that in HFD and STZ induced diabetic rats ginger plays an important role in lowering the glucose level and increasing the insulin levels to control the the blood glucose levels. This investigation was further supported by (Nammi *et al*., 2009) in his studies concluded that the ethanolic extract of ginger at 100, 200 and 400 mg/kg for six weeks in animal models shows significant increase in body weight, insulin, HDL and a reduction is observed in the LDL triglycerides free fatty acids and phospholipids.

Furthermore, Singh *et al*. (2008) reported that the 6-gingerol at the dose of 100mg/kg showed reduction in blood glucose

level, triglycerides, total cholesterol, free fatty acids lipoproteins and increase in insulin levels. Recently, the effect of ginger powder (200 mg/kg) was examined in type-2 diabetic animal models. The results described that the decrease of blood glucose, total lipid, and an increase in total antioxidant level (Madkor *et al*., 2011). Abdulrazaq *et al*. (2011) was described that the effect of long term administration of ginger in the type-1 diabetic rats reduces the blood glucose level total cholesterol, triglycerides, enhance the insulin levels and prevent the animals from body weight kidney and liver weight losses. The ethyl acetate extract of ginger decrease lipid content in 3T3 adipocyte, inhibited proteinglycation and encourage the glucose uptake and GLUT4 expression in L6 myotube cell surface (Noipha *et al*., 2010; Rani *et al*., 2012).

Most of the studies have proven 6- gingerol a main bioactive moiety of ginger which contributes in controlling the metabolic syndromes. It facilitates the insulin independent glucose intake by enhancing the translocation of glucose transporter GLUT4 to the muscle cell plasma membrane surface, together with small increases in total GLUT4 protein expression. In biomodeling trails it was examined that the slight polar nature of 6-gingerol specifically (S)-6- and (S)-8 gingerol significantly increase the glucose uptake in L6 cultured rat skeletal muscle cells (Noipha *et al*., 2010). Besides all the studies, some data is also available on human trails. In a study 3g ginger powder for 30 days was given to diabetic patients through diet and effect was observed that significant decreased in VLDL, LDL, total cholesterol, triglyceride, blood glucose (Andallu *et al*., 2003).

Ginger extracts rich in phenolic compounds like mainly gingerols and shogaols which are correlated with inhibition of glucose metabolic enzymes. In a study, it was described that among the ginger extracts prepared by using conventional solvents (Hexane, ethyl acetate, methanol, water) ethyl acetate had maximum inhibitory activity against α-glucosidase and α-amylase with IC50 value 180 mg/ML and 980mg/ML. These two key enzymes are related with hyperglycemia and type-2 diabetes (Rani *et al*., 2012). In another study the aqueous extract of ginger have very low inhibitory effect against α-glucosidase and α-amylase due to low phenolic contents (Ranilla *et al*., 2010).

The basic causes of diabetes mellitus are problems in insulin sensitivity/release. In vivo analysis it was examined that ginger played marvelous role in increasing insulin level with reducing effect on glucose concentration in blood. The administration of 6-gingerol in arsenic-induced type-2 diabetic animals, explained that 6-gingerol have protective effect on pancreatic β-cells and helps in maintaining blood insulin levels (Chakraborty *et al*., 2012).

***Hyper-cholesterolemic Effect of Ginger*:** Cardiovascular disorders (CVD) are a main reason of morbidity and death in the globe. The varying daily life and food patterns are most important causative issue in the occurrence and pathogenesis of CVD (Matsuura *et al*., 2008). The phytochemicals of ginger are considered as remedy in many physiological fears. Its nutraceutical components are playing a significant role in the prevention of CVD. Besides this, some evidences are found about its therapeutic effects in many diseases like cancer, hypotensive, antiplatelet, anti-inflammatory, and hypolipidemic effects and in many others. In many in vitro and in vivo studies shown that ginger and ginger products are gaining much fame, due to their preventing effects against cardiovascular disease (Nicoll and Henein 2009). In many studies its cholesterol lowering and CVD preventing effects are shown.

Bhandari *et al*. (2005) investigated that ginger extract have antihyperlipidemic and antiatherosclerosis effect. The ginger extract significantly reduces the cholesterol levels in rabbit which fed on high cholesterol diet as compared to control group. Further the previous study was supported by Fuhrman *et al*. (2000). In this investigation, it was resulted that the consumption of ginger extract lowered the atherosclerotic lesion areas, cholesterol, LDL, triglycerides in mices, which were the main cause of its happening. Later on the same lipid lowering activity in comparison with a cholesterol reducing drug was reported by Bhandari *et al*. (2005) and also linked this activity with the presence of nutraceutical components of ginger extract.

The supplementation of ginger in diet is done to improve lipid profiles significantly. Its consumption reduces the formation of cholesterol in liver and enhances the conversion of cholesterol into bile acids and excretory systems (Verma *et al*., 2004). In result, due to the cholesterol lowering potential of ginger extract, a significant reduction is observed in cellular cholesterol accumulation. It was also examined ginger extract administration reducedcholesterol level and foam cell formation after administration of cholesterol rich diet foam cell formation, which were considered as basic causes of atherosclerosis (Fuhrman *et al*., 2000).

The consumption of ethanolic extract of ginger in apolipoprotein E-deficient mice over 10 weeks reduces the risk of CVD in dose dependent manners. It also reduces the oxidation and aggregation of LDL and significant reduction also reported in LDL cholesterol basal oxidative state (Fuhrman *et al*., 2000). In cholesterol fed rabbits it was investigated that the oral administration of ginger powder at 0.1 g/kg of body weight for 75 days reduced the risk of atheroma development in coronary arteries up to 50%. This preventive effect of ginger is linked with the reduction of lipid peroxidation and boosting fibrinolytic activity in animal trails (Verma *et al*., 2004).

Further, hypocholesterolemic of ginger was documented by Alizadeh-Navaei *et al*. (2008). In this study, it was examined that the consumption of ginger at the dose of 3g/day by volunteer's patients in controlled clinical trials considerably improved the lipid profiles and reduced the LDL-cholesterol, VLDL and triglyceride as compared to placebo group. A

significant increment was observed in HDL level of the ginger administrated group then placebo group.

Ginger was also reported to slightly reduce retinoid-binding protein mRNA expression levels in liver and visceral fat in male rats that were fed cholesterol to induce hyperlipidemia. These results hint that ginger consumption might improve lipid metabolism. Besides, at cellular level it was investigated lipid profile was improved due to ginger nutraceutical components which lowered the sretinoid binding protein (RBP) mRNA expression levels in the liver and visceral fat in cholesterol induced hyperlipidemic male rats (Matsuda *et al*., 2009).

In the diabetic rats it was reported that the high levels of blood cholesterol reduced the insulin activity and glucose metabolism in peripheral tissues (McGarry, 2002). Li *et al*. (2012) studied that the higher levels of free fatty acids and fatty acid oxidation significantly reduce the glucose transport within body tissues, this leads to the different metabolic disorders. In many animal models the insulin sensitivity, antiobese and lipid lowering effect of ginger was documented (Andallu *et al*., 2003). The uses of ginger alone or with other herbs have significant reduction in body weight, cholesterol and serum triglycerides in diabetic and hyperlipidemic patients (Nammi *et al*., 2009).

During another 64 days experimental trail conducted by Weidner and Sigwart (2000) it is presented that the ginger extract rich in gingerols and shogaols at the dose of 25–100 mg/kg of body weight have no significant effect on the blood pressure, heart rate and cholesterol level in normal rats, but it effectively reduces the blood LDL level in hyperglycemic rats. The extract has an increasing impact on HDL in blood of high-fat-fed rats (Fuhrman *et al*., 2000). A research has shown that ginger intake of 2-5 % in preventive and curative groups of rats shows the enhanced glutathione activity and reduced plasma lipid peroxide levels (Liu *et al*., 2003). The present discussion concludes that ginger is of significant importance in improving lipid profile and its cholesterol lowering ability is indeed imperative in controlling the extent of hypertension, arthrosclerosis and allied cardiovascular disorder.

Conclusion: The increasing demand of the nutritional therapies motivates the researchers and processores of food to introduce some food products with therapeutic potentional. Although, many investigations are done but still areas need to be explored to find out the role of therapeutic components, their mechanisam of action, effect of processing, application and safety.

REFERENCES

Abdulrazaq, N.B., Cho, M.M., N.N. Win, R. Zaman and M.T. Rahman. 2012. Beneficial effects of ginger (Zingiberofficinale) on carbohydrate metabolism in streptozotocin-induced diabetic rats. Br. J. Nutr.108:1194.

Ahmed, R and S. Sharma. 2007. Biochemical studies on combined effect of garlic (Allium sativum Linn) and ginger (ZingiberofficinaleRosc) in albino rats. Indian J. Expl. Boil.35:841-843.

Akhani, S.P., S.L. Vishwakarma and R.K. Goyal. 2004. Anti-diabetic activity of Zingiberofficinale in streptozotocin-induced type I diabetic rats. J. Pharmac Pharmacal.56:101-105.

Al-Amin, Z.M., M. Thomson.K.K. Al-Qattan, R. Peltonen-Shalaby and M. Ali. 2006. Anti-diabetic and hypolipidaemic properties of ginger (Zingiberofficinale) in streptozotocin-induced diabetic rats. Br. J. Nutr. 96:660-666.

Ali, B.H., G. Blunden, M.O. Tanira and A. Nemmar. 2008. Some phytochemical, pharmacological and toxicological properties of ginger (Zingiberofficinale): a review of recent research. Food Chem. Toxicol. 46:409-420.

Alizadeh-Navaei, R., F. Roozbeh, M. Saravi, M. Pouramir, F. Jalali and A.A. Moghadamnia. 2008. Investigation of the effect of ginger on the lipid levels. a double blind controlled clinical trial. Saudi Med. J. 29:1280-1284.

Al-Johar, D., N. Shinwari, J. Arif, N. Al-Sanea, A.A. Jabbar, R. El-Sayed, A. Mashhour, G. Billedo, I. El-Doush and I. Al-Saleh. 2008. Role of Nigella sativa and a number of its antioxidant constituents towards azoxymethane-induced genotoxic effects and colon cancer in rats. Phytother. Res. 22:1311-1323.

Al-Othman, A.M., F. Ahmad, S. Al-Orf, S.K. Al-Murshed and Z. Arif. 2006. Effect of dietary supplementation of Ellatariacardamomum and Nigella sativa on the toxicity of rancid corn oil in Rats. Int. J. Pharmacol. 2:60-65.

Al-Qattan, K., M. Thomson and M. Ali. 2008. Garlic (Allium Sativum) and ginger (Zingiberofficinale) attenuate structural nephropathy progression in streptozotocin-induced diabetic rats. Eur. J. Clin. Nutr.Metabol. 3:62-71.

Andallu, B., B. Radhika and V. Suryakantham. 2003. Effect of aswagandha, ginger and mulberry on hyperglycemia and hyperlipidemia. Plant Foods Human Nutr.58:1-7.

Balachandran, S., S.E. Kentish and R. Mawson. 2006. The effect of both preparation method and season on the supercritical extraction of ginger. Sep. Purif. Technol.48:94-105.

Balladin, D.A., O. Headley, I. Chang-Yen and D.R. McGaw. 1998. High pressure liquid chromatographic analysis of the main pungent principles of solar dried west indian ginger (Zingiberofficinale). Renewable energy. 13:531-536.

Bárta, I., P. Smerák, Z. Polívková, H. Sestáková, M. Langová, B. Turek and J. Bártová. 2006. Current trends and perspectives in nutrition and cancer prevention. Neoplasma.53:19-25.

Bartley, J. and A. Jacobs. 2000. Effects of drying on flavour compounds in Australian-grown ginger (Zingiberofficinale). J. Sci. Food Agric.80:209-215.

Bhandaria, U., R. kanojia and K.K. Pillai. 2005. Effect of ethanolic extract ofZingiberofficinaleondyslipidaemia in diabetic rats. J. Ethnopharmacolo.97:227-230.

Bhattarai, S., V.H. Tran, and C.C. Duke. 2001. The stability of gingerol and shogaol in aqueous solutions. J. Pharm. Sci. 90:1658-1663.

Bjelakovic, G., D. Nikolova, L.L. Gluud, R.G. Simonetti and C. Gluud. 2007. Mortality in randomized trials of antioxidant supplements for primary and secondary prevention: Systematic review and meta-analysis.JAMA. 297:842-857.

Butt, M.S. and M.T. Sultan. 2011. Ginger and its health claims: Molecular aspects. Cri. Rev. Food Sci. Nutr.51:383-393.

Butt, M.S., M.T. Sultan, F.M. Anjum, M.K. Shareef and S.H. Khan. 2007. Functional foods: emerging trend in nutritional support programs. In: Proceedings of the International Symposium on Emerging Trends in Food Science & Technology, Faisalabad, Pakistan, November 6-8, 2007.

Chakraborty, D., A. Mukherjee, S. Sikdar, A. Paul, S. Ghosh and A.R. Khuda-Bukhsh. 2012. [6]-Gingerol isolated from ginger attenuates sodium arsenite induced oxidative stress and plays a corrective role in improving insulin signaling in mice. Toxicol.Letters. 210:34-43.

Chan, E.W.C., Y.YLim, S.K. Wong, K.K. Lim, S.P. Tan, F. S. Lianto and M.Y. Yong. 2009. Effects of different drying methods on the antioxidant properties of leaves and tea of ginger species. Food Chem. 113:166-172.

Chauhan, B., G. Kumar, N. Kalam and S.H. Ansari. 2013. Current concepts and prospects of herbal nutraceutical: A review. J adv. Pharma. Technol. Res. 4:4-8

Chen, M., X. Liu, X. Dong, M. Jiang, X. Lv and G. Yan. 2008. Antioxidant activity and phenolics of an endophyticXylaria sp. from Gingko biloba. Food Chem. 105:548-554

Chrubasik, S., M.H. Pittler and B.D. Roufogalis. 2005. Zingiberisrhizoma: a comprehensive review on the ginger effect and efficacy profiles. Phytomed. 12:684-701.

Diaz-Reinoso, A.B. Moure, H. Dominguez and J.C. Parajó. 2006. Supercritical CO2 extraction and purification of compounds with antioxidant activity. J. Agric. Food Chem. 54:2441-2469.

Dugasani, S., M.R. Pichika, V.D. Nadarajah, M.K. Balijepalli, S. Tandra, J. N. Korlakunta. 2010. Comparative antioxidant and anti-inflammatory effects of [6]-gingerol, [8]-gingerol, [10]-gingerol and [6]-shogaol. J Ethnopharmacol. 127:515-20.

Ebru, U., U. Burak, S. Yusuf, B. Reyhan, K. Arif, T.H. Faruk, M. Emin, K. Aydın, I.L. Atilla, S. Semsettin and E. Kemal. 2008. Cardioprotective Effects of Nigella 230 sativa Oil on Cyclosporine A-Induced Cardiotoxicity in Rats. Basic Clin.Pharmacol.Toxicol.(In press).

Eckel, R.H., S. M. Grundy and P.Z. Zimmet. 2005. The metabolic syndrome. The Lancet. 365:1415-1428.

El-Sharaky, A.S., A.A. Newairy, M.A. Kamel and S.M. Eweda. 2009. Protective effect of ginger extract against bromobenzene-induced hepatotoxicity in male rats. Food Chem. Toxicol. 47:1584-1590.

Engdal, S., O. Klepp and O.G. Nilsen. 2009. Identification and exploration of herb-drug combinations used by cancer patients. Integra. Cancer Therap.1:29-36.

Eskin, N.A.M. and S. Tamir. 2006. Ginger-gingerol.In:Dictionary of Nutraceuticals and Functional Food, pp. 184–186. Eskin N.A.M. and Tamir S., Eds., CRC Press, Boca Raton, FL.

Evans, W.C. 2002. Ginger Trease and Evans Pharmacognosy, 15th Ed. WB Saunders, Edinburgh, UK.277-280.

FAOSTAT. 2011. Food and Agriculture Organization of the United Nation. USA. Available on http://faostat3.fao.org/home/index.html. Accessed on: Date 16-04-2013: Time 12:00 pm.

Francisco, J.D.C. and E.S. Dey. 2003. Supercritical fluids as alternative, safe, food-processing media: an overview. Acta.Microb. Polonica.52:35-43.

Frighetto, R.T., R.M. Welendorf, E.N. Nigro, N. Frighetto, A.C. Siani. 2008. Isolation of ursolic acid from apple peels by high speed counter-current chromatography. Food Chem.106:767-771.

Fuhrman, B., M. Rosenblat, T. Hayek, R. Coleman and M. Aviram. 2000. Ginger extract consumptionreducesplasmacholesterol,inhibitsLDLoxidationandattenuates development of atherosclerosis in atherosclerosis in atherosclerotic apolipoproteinEdeficient mice. J. Nutr. 130:1124-1131.

German, J.B., and R.L. Walzem . 2000. The health benefits of wine. Ann. rev. nutr.20: 561-593.

Ghasemzadeh, A., H.Z. Jaafar and A. Rahmat. 2010. Identification and concentration of some flavonoid components in Malaysian young ginger (Zingiberofficinale) varieties by a high performance liquid chromatography method. Molecules. 15:6231-6243.

Gidding, S.S., B.A. Dennison, L.L. Birch, S.R. Daniels, M.W. Gilman, A.H. Lichtenstein, K.T. Rattay, J. Steinberger, N. Stettler and L. Van Horn. 2005. Dietary recommendations for children and adolescents: a guideline for ractitioners. Consensus Statement from the American Heart Association. Circulation.112:2061-2075.

Girgih, A.T., S.B. Myrie, R.E. Alukoand P.J.H. Jones. 2013. Is category 'A' status assigned to soy protein and coronary heart disease risk reduction health claim by the

United States Food and Drug Administration still justifiable.Tren.in Food Sci.Technol,30:121-132.

Goyal, R.K. and S.V. Kadnur. 2006. Beneficial effects of Zingiberofficinale on goldthioglucose induced obesity. Fitoterapia.77:160-163.

Grant, K.L. and R.B. Lutz. 2000. Ginger. Am. J. Health Syat. Pharm. 57:945-947.

Grzanna, R., L. Lindmark and C.G. Frondoza. 2005. Ginger: an herbal medicinal product with broad anti-inflammatory actions. J. Med. Food. 8:125-132.

Han, C.M., K.W. Pan, N. Wu, J.C. Wang and W. Li. 2008.Allelopathic effect of ginger on seed germination and seedling growth of soybean and chive.Scientia Horti.116:330-336.

Harold, M. 2004. Black pepper and relatives on food cocking revised ed. pp. 427-429.

Heimes, K., B. Feistel and E.J. Verspohl. 2009. Impact of the 5-HT3 receptor channel system for insulin secretion and interaction of ginger extracts. Euro. J. Pharmacol, 624:58-65.

Hu, F.B., and W.C. Willett. 2002. Optimal diets for prevention of coronary heart disease. J. Am. Med. Assoc., 2188:2569-2578.

Huang, G.J., J.S. Deng, H.J. Chen, S.S. Huang, C.H. Wu, J.C. Liao and Y.H. Lin. 2012. Inhibition of reactive nitrogen species and vivo by thioredoxin from sweet potato 'Tainong 57'storage roots. Food Chem.131:552-557.

Hussein, M.R., E.E. Abu-Dief, M.H. Abd El-Reheem and A. Abd-Elrahman. 2005. Ultrastructural evaluation of the radioprotective effects of melatonin 237 against X-ray-induced skin damage in Albino rats. Int. J. Exp. Pathol. 86:45-55.

Ibrahim, K.A.B. 2006. Extraction of essentional oils from ginger rhizome using steam distillation method. Ph.D diss. University College of Engineering and Technology. Pahang, Malaysia.

Ippoushi, K., K. Azuma, H. Ito, H. Horie and H. Higashio. 2003.Gingerol inhibits nitric oxide synthesis in activated J774.1 mouse macrophages and prevents peroxynitrite-induced oxidation and nitration reactions. Life Sci., 73:3427-3437.

Isa, Y., Y. Miyakawa, M. Yanagisawa, T. Goto, M.S. Kang, T. Kawada and T. Tsuda. 2008. 6-Shogaol and 6-gingerol, the pungent of ginger, inhibit TNF-α mediated downregulation of adiponectin expression via different mechanisms in 3T3-L1 adipocytes. Biochem.Biophys. Res. Commun. 373:429-434.

Islam, M.S. and C. Haymie. 2008. Comparative effects of ginger (Zingiberofficinale) and garlic (Allium sativum) investigated in type 2 diabetes model of rats. J. Med. Food.11:152-159.

Ismail, H. I., K. W. Chan, A. A. Mariod and M. Ismail. 2010. Phenolic content and antioxidant activity of cantaloupe (cucumismelo) methanolic extracts. Food Chem. 119: 643-647.

Jaleel, K. and B. Sasikumar. 2012. Characterization of ginger (Zingiberofficinale) germplasm based on volatile and non-volatile components. Afric. J. Biotechnol. 11:777-786.

Jang, H.D., K.S. Chang, Y.S. Huang, C.L. Hsu, S.H. Lee and M.S. Su. 2007. Principal phenolic phytochemicals and antioxidant activities of three chinese medicinal plants. Food Chem.103:749-756.

Jenkins, D.J., C.W. Kendall, T.H. Nguyen, A. Marchie, D.A. Faulkner, C. Ireland, A.R. Josse, E. Vidgen, E.A. Trautwein, K.G. Lapsley, C. Holmes, R.G. Josse, L.A. Leiter, P.W. Connelly and W. Singer. 2008. Effect of plant sterols in combination with other cholesterol-lowering foods. Metabolism. 57:130-139.

Jolad, S.D., R.C. Lantz, A.M. Solyom, G. J. Chen, R.B. Bates and B.N. Timmermann. 2004. Fresh organically grown ginger (Zingiberofficinale) composition and effects on LPS-induced PGE production. Phytochem. 65:1937-1954.

Jones, P.J. and K.A. Varady. 2008. Are functional foods redefining nutritional requirements? Appl. Physiol. Nutr. Metab.33:118-123.

Kadnur, S.V. and R.K. Goyal. 2005. Beneficial effects of Zingiberofficinale Roscoe of fructose induced hyperlipidemia and hyperinsulinemia in rats. Indian J. Exp. Biol.43:1161-1164.

Kanter, M. 2008. Effects of Nigella sativa and its major constituent, thymoquinone on sciatic nerves in experimental diabetic neuropathy.Neurochem. Res.33:87-96.

Kelly, C.Z., M.O.M. Marques, A.J. Petenate and M.A.A. Meireles. 2002. Extraction of ginger (Zingiberofficinale Roscoe) oleoresin with CO2 and co-solvents: a study of the antioxidant action of the extracts. J. Supercrit. Fluids. 24:57-76.

Khattak, K.F., T.J. Simpson and Ihasnullah. 2008. Effect of gamma irradiation on the extraction yield, total phenolic content and free radical-scavenging activity of Nigella staiva seed. Food Chem. 110:967-972.

Kim, J.I., J.K. Paik, O.Y. Kim, H.W. Park, J.H. Lee, Y. Jang and J.H. Lee. 2011. Effects of lycopene supplementation on oxidative stress and markers of endothelial function in healthy men. Atherosclerosis. 215:189-195.

Kim, Jiyoung, K. Jaekyoon, S. Jaesung, Y.L. Chang, W.L. Ki and J.L. Hyong. 2013. Cocoa phytochemicals: recent advances in molecular mechanisms on health." Critic. Rev. in Food Sci. Nutr.(Just accepted).

Kota, N., P. Krishna and K. Polasa. 2008. Alterations in antioxidant status of rats following intake of ginger through diet. Food Chem.106:991-996.

Kota, S.K., S. Jammula, K.S.V. Satya, L.K. Meher, E.S. Rao and K.D. Modi. 2012. Nutraceuticals in pathogenic

obesity; striking the right balance between energy imbalance and inflammation. J. Med. Nutr. Nutra.1:63.

Langer, E., S. Greifenberg and J. Gruenwald. 1998. Ginger: history and use. Adv. Ther. 15:25-44.

Lantz, R.C., G.J. Chen, M. Sarihan, A.M. Solyom, S.D. Jolad and Timmermann. 2007. The effect of extract from ginger rhizome on inflammatory medicator production. Phytomedicine.14:123-128.

Lapshina, E.A., E.J. Sudnikovich, J.Z. Maksimchik, S.V. Zabrodskaya, L.B. Zavodnik, V.L. Kubyshin and I.B. Zavodnik. 2006. Antioxidative enzyme and glutathione transferase activities in diabetic rats exposed to long-term ASA treatment. Life Sci.79:1804-1811.

Li, G.Q., K.K.H. Antony, Wong, Z. Xian, A. Eshaifol, Omar, A. Ali, M.L. Kong, R.N. Valentina and C. Kelvin. 2013. "Herbal medicines for the management of diabetes". In Diabetes, pp. 396-413.Springer New York, USA.

Li, Y., V.H. Tran, C. C. Duke and B. D. Roufogalis.2012. Gingerols of Zingiberofficinaleenhance glucose uptake by increasing cell surface GLUT4 in cultured L6 myotubes. Planta Medica.78:1549-1555.

Lim, Y.Y. and J. Murtijaya. 2007. Antioxidant properties of (PhyllanthusAmarus) extracts as affected by different drying methods. LWT-Food Sci. and Technol.40:1664-1669.

Liu,N., G. Huo, L. Zhang and X. Zhang. 2003.EffectofZingiberOfficinaleRoseonlipidperoxidatio ninhyperlipidemiarats.Wei Sheng Yan Jiu, 32:22-23.

Liu-Stratton, Y., S. Roy and C.K. Sen. 2004.DNA microarray technology in nutraceutical and food safety.Toxicol.Lett. 150:29-42.

Madkor, H.R., S.W. Mansour and G. Ramadan. 2011. Modulatory effects of garlic, ginger, turmeric and their mixture on hyperglycaemia, dyslipidaemia and oxidative stress in streptozotocin–nicotinamide diabetic rats. Brit. J. Nutr. 105:1210.

Mallikarjuna, K., C.P.S. Sahitya, K. Reddy, W. Rajendra. 2008. Ethanol toxicity: rehabilitation of hepatic antioxidant defense system with dietary ginger. Fitoterapia. 79:174-178.

Manach, C., A. Scalbert, C. Morand, C. Rémésy and L. Jiménez. 2004. Polyphenols: food sources and bioavailability. Am. J. Clin. Nutr.79:727–747.

Marriott, B.M. 2000. Functional foods: an ecologic perspective1–3. Am. J. Clin. Nutr. 71:1728S–1734S.

Masuda, Y., H. Kikuzaki, M. Hisamoto and N. Nakatani. 2004. Antioxidant properties of gingerol related compounds from ginger. Biofactors. 21:293-296.

Matsuda, A., Z. Wang, S. Takahashi, T. Tokuda, N. Miura and J. Hasegawa. 2009. Upregulation of mRNA of retinoid binding protein and fatty acid binding protein by cholesterol enriched-diet and effect of ginger on lipid metabolism. Life Sci. 84: 903-907.

Matsuura, E., G.R. Hughes and M.A. Khamashta. 2008. Oxidation of LDL and its clinical implication. Autoimmun.Rev. 7:558-566.

McGarry, J. D. 2002. Dysregulation of fatty acid metabolism in the etiology of type 2 diabetes, Diab,51(1):7-18.

Misra, A., N.K. Alappan, N.K. Vikram, Goel, N. Gupta, K. Mittal and K. Luthra. 2008. Effect of supervised progressive resistance-exercise training protocol on insulin sensitivity, glycemia, lipids, and body composition in asianindians with type 2 diabetes. Diabetes Care. 31:1282-1287.

Nammi, S., S. Sreemantula and B.D. Roufogalis. 2009. Protective effects of ethanolic extract of zingiberofficinale rhizome on the development of metabolic syndrome in high-fat diet-fed rats. Basic Clini.Pharma.Toxicol. 104:366-373.

Nicoll, R. and M.Y. Henein. 2009. Ginger (Zingiberofficinale): a hot remedy for cardiovascular disease. Int. J. Cardiol. 131:408-409.

Nirmala, K., T.P. Krishna and K. Polasa. 2010. Modulation of xenobiotic metabolism in ginger (Zingiberofficinale) fed rats. Int. J. Nutr. Metab. 3:56-62.

Noipha, K., S. Ratanachaiyavong and P. Ninla-aesong. 2010. Enhancement of glucose transport by selected plant foods in muscle cell line L6. Diab. Res. Clin. Prac 89:22-26.

Odebunmi, E.O., Oluwaniyi, O.O. and Bashiru M.O. 2009.Comparative Proximate Analysis of Some Food Condiments. J. App.Sci.Res, 1-3.

Ojewole, J.A.O., 2006. Analgesic, antiinflammatory and hypoglycaemic effects of ethanol extract of Zingiberofficinale (Roscoe) rhizomes (Zingiberaceae) in mice and rats. Phytothera. Res. 20:764-772.

Pandey, G. 2013. Some medicinal plants to treat fish ectoparasitic infections. Int. J. Pharm. Res. Sci.2(2):532-538.

Park, J., H. Hwang, .J. Lee. 2006. Quality of ginger powder as affected by concentration and dehydration methods of ginger extracts Korean J. Food Sci. Technol. 36:311-318.

Park, S.H., M.S. Kyeong, Y. Hwang, S.Y. Ryu, S.B. Han and Y. Kim. 2012. Inhibition of LPS binding to MD-2 co-receptor for suppressing TLR4-mediated expression of inflammatory cytokine by 1-dehydro-10-gingerdione from dietary ginger. Biochem.Biophys. Res. Commun.419:735-740.

Peter, K.V. 2001.Handbook of Herbs and Spices.Woodhead Publishing Limited. Abington, Cambridge, UK.234-260.

Pittler, M.H., K. Schmidt and E. Ernst. 2005. Adverse events of herbal food supplements for body weight reduction: systematic review. Obesity rev. 6:93-111.

Puengphian, C and A. Sirichote. 2008. [6]-gingerol content and bioactive properties of ginger (Zingiberofficinale) extracts from supercritical CO2 extraction. As. J. Food Ag. Ind. 1:29-36.

Rains, T.M., S. Agarwal and K.C. Maki. 2011. Antiobesity effects of green tea catechins: a mechanistic review. J. Nutr. Biochem. 22:1-7.

Ramaa, C.S., A.R. Shirode, A.S. Mundada and V.J. Kadam. 2006. Nutraceuticals-an emerging era in the treatment and prevention of cardiovascular diseases. Current pharma. Biotechnol.7:15-23.

Rani, M.P., M.S. Krishna, K.P. Padmakumari, K.G. Raghu and A. Sundaresan. 2012. Zingiberofficinale extract exhibits anti-diabetic potential via modulating glucose uptake, protein glycation and inhibiting adipocyte differentiation: an in vitro study. J. Sci. Food Agric. 92: 1948-1955.

Ranilla, L.G., Y.I. Kwon, E. Apostolidis and K. Shetty. 2010. Phenolic compounds, antioxidant activity and in vitro nhibitory potential against key enzymes relevant for hyperglycemia and hypertension of commonly used medicinal plants, herbs and spices in Latin America. Bioresou.Technolo. 101:4676-4689.

Reddy, V., A. Urooj and A. Kumar. 2005. Evaluation of antioxidant activity of some plant extracts and their application in biscuits. Food Chem. 50:6550-6556.

Retelny, V.S., A. Neuendorf and J.L. Roth. 2008. Nutrition protocols for the prevention of cardiovascular disease. Nutr.Clin.Pract. 23:468-476.

Roy, M.K., M. Takenaka, S. Isobe and T. Tsushida.2007. Antioxidant potential, anti-proliferative activities, and phenolic content in water-soluble fractions of some commonly consumed vegetables: effects of thermal treatment. Food Chem. 103:106-114.

Sasidharan, I., V.V. Venugopal and A.N. Menon. 2012. Essential oil composition of two unique ginger (Zingiberofficinale) cultivars from Sikkim. Natural Product Res. 26:1759-1764.

Schwager, J., M.H. Mohajeri, A. Fowler and P. Weber. 2008. Challenges in discovering bioactives for the food industry. Curr.Opin.Biotechnol. 19:66-72.

Schwertner, H.A. and D.C. Rios. 2007. High-pressure liquid chromatographic analysis of 6- gingerol, 8-gingerol, 10-gingerol, and 6-shogaol in ginger containing dietary supplements, spices, teas, and beverages. J. Chrom. 856:41-47.

Sekiya, K., A. Ohtani and S. Kusano. 2004. Enhancement of insulinsensitivity in adipocytes by ginger. Bio. Factors, 22:153-156.

Sethi, G., K.S. Ahn and B.B. Aggarwal. 2008. Targeting nuclear factor-kappa B activation pathway by thymoquinone:role in suppression of antiapoptotic gene products and enhancement of apoptosis. Mol. Cancer Res. 6:1059-70.

Shahidi, F. 2009. Nutraceuticals and functional foods: whole versus processed foods. Trends Food Sci.Technol. 20:376-387.

Shukla, Y. and M. Singh. 2007. Cancer preventive properties of ginger: a brief review. Food Chem.Toxicol.45:683-690.

Singh,G.,I.S.Kapoor,P.Singh,C.S.Heluani,M.P.Lampasona,C .A.N.Catalan. 2008.Chemistry,antioxidantandantimicrobialinvestigatio nonessentialoiland oleoresine of Zingiberofficinale. Food Chem. Toxicol.46: 3295-3302.

Tanaka, T., H. Kohno and H. Mori. 2001. Chemoprevention of Colon Carcinogenesis by Dietary Non-nutritive Compounds. Asian Pac. J. Cancer Prev. 2:165-177.

Tapsell, L.C., I. Hemphill, L. Cobiac, D.R. Sullivan, M. Fenech, C.S. Patch and K.E. Inge. 2006. Health benefits of herbs and spices: the past, the present, the future. Faculty of Health and Behavioural Sciences-Papers.

Temple, N. J. and G.K. Kaiser. 2003. Fruit, vegetables, and the prevention of cancer: research challenges. Nutrition, 19:467-470.

Thielecke, F. and M. Boschmann. 2009. The potential role of green tea catechins in the prevention of the metabolic syndrome - a review. Phytochem. 70:11-24.

Topic, B., R.U. Hasenöhrl, R. Häcker, J. P. Huston. 2002. Enhanced conditioned inhibitory avoidance by a combined extract of (Zingiberofficinale) and Ginkgo biloba. Phytother Res. 16:312-5.

Turkmen, N., F. Sari and Y. SedatVelioglu. 2005. The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables. Food Chem.93:713-718.

Urala, N. and L. Lähteenmäki. 2007. Consumers' changing attitudes towards functional foods. Food Qual. Prefer. 18:1-12.

Uz, E., O.F. Karatas, E. Mete, R. Bayrak, O. Bayrak, A.F. Atmaca and A. Akcay. 2009. The effect of dietary ginger (Zingiberofficinale) on renal ischemia/reperfusion injury in rat kidneys. Renal failure. 31:251-260.

Verma, S. K., M.J. Singh and A. Bordia. 2004. Protective effect of ginger, Zingiberofficinale Rose. on experimental atherosclerosis in rabbits. Indian J. Exp. Biol.42:736-738.

Vina, J., C. Borras, M.C. Gomez-Cabrera and W.C. Orr. 2006. Part of the series: from dietary antioxidants to regulators in cellular signalling and gene expression. Role of reactive oxygen species and (phyto)oestrogens in the modulation of adaptive response to stress. Free. Radic. Res.40:111-119.

Wang, W., C.Y. Li, X.D. Wen, P. Li and L.W. Qi. 2009. Simultaneous determination of 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaol in rat plasma by liquid chromatography-mass spectrometry: application to pharmacokinetics. J. Chromatogr. B. 877: 671-679.

Wang, X., Z. Zheng, X. Guo, J. Yuan and C. Zheng. 2011. Preparative separation of gingerols from (Zingiberofficinale) by high-speed counter-current

chromatography using stepwise elution. Food Chem. 125:1476-1480.

Weidner, M.S. and K. Sigwart. 2000. The safety of a ginger extract in the rat. J. Ethnopharmacol.73:513-520.

Wohlmuth, H., D.N. Leach, M.K. Smith and S.P. Myers. 2005. Gingerol content of diploid and tetraploid clones of ginger (Zingiberofficinale). J. Agric. Food Chem.53:5772-5778.

Yanishlieva, N.V., E. Marinova and J. Pokorný. 2006. Natural antioxidants from herbs and spices. Eur. J. Lipid Sci. Technol. 108:776-793.

Zancan, K.C., M.O.M. Marques, A.J. Petenate, M.A.A. Meireles. 2002. Extraction of gin-ger (Zingiberofficinale) oleoresin with CO2 and co-solvents: a study of the antioxidant action of the extracts. J. Supercrit. Fluids 24:57-76.

Zhan, K., K. Xu and H. Yin. 2011. Preparative separation and purification of gingerols from ginger (Zingiberofficinale) by high-speed counter-current chromatography. Food Chem. 126:1959-1963.

Zock, P.L. and M.B. Katan. 2008. Diet, LDL oxidation, and coronary artery disease. Am. J. Clin. Nutr.68:759-760.